Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCE
In Physics (9PH0)
Paper 01: Advanced Physics I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the MS has specified specific words that must be present. Such words will be indicated by underlining e.g. 'resonance'

1.2 Bold lower case will be used for emphasis e.g. '**and'** when two pieces of information are needed for 1 mark.

1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".

1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally mean that the final calculation mark will not be awarded.

2.2 This does not apply in 'show that' questions or in any other question where the units to be used have been given, for example in a spreadsheet.

2.3 The mark will not be awarded for the same missing or incorrect unit only once within one clip in epen.

2.4 Occasionally, it may be decided not to insist on a unit e.g the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.

2.5 The mark scheme will indicate if no unit error is to be applied by means of [no ue].

3. Significant figures

3.1 Use of too many significant figures in the theory questions will not be prevent a mark being awarded if the answer given rounds to the answer in the MS.

3.2 Too few significant figures will mean that the final mark cannot be awarded in 'show that' questions where one more significant figure than the value in the question is needed for the candidate to demonstrate the validity of the given answer.

3.3 The use of one significant figure might be inappropriate in the context of the question e.g. reading a value off a graph. If this is the case, there will be a clear indication in the MS.

3.4 The use of g = 10 m s^{-2} or 10 N kg^{-1} instead of 9.81 m s^{-2} or 9.81 N kg^{-1} will mean that one mark will not be awarded. (but not more than once per clip). Accept 9.8 m s^{-2} or 9.8 N kg^{-1}

3.5 In questions assessing practical skills, a specific number of significant figures will be required e.g. determining a constant from the gradient of a graph or in uncertainty calculations. The MS will clearly identify the number of significant figures required.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks. then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

Question Number	Acceptable answers	Additional guidance	Mark
1	**The only correct answer is C** A is not the correct answer, as there are 8 protons and 9 neutrons. B is not the correct answer, as there are 8 protons and 9 neutrons. D is not the correct answer, , as there are 8 protons and 9 neutrons.		**1**
2	**The only correct answer is C** A is not the correct answer, as a baryon has three quarks. B is not the correct answer, as leptons are fundamental particles D is not the correct answer, as a nucleon is a proton or neutron		**1**
3	**The only correct answer is D** A is not the correct answer, as $-\frac{t}{T} = \ln\frac{1}{2}$ B is not the correct answer, as $-\frac{t}{T} = \ln\frac{1}{2}$ C is not the correct answer, as $-\frac{t}{T} = \ln\frac{1}{2}$		**1**
4	**The only correct answer is A** B is not the correct answer, as both mass and lifetime both increase. C is not the correct answer, as both mass and lifetime both increase. D is not the correct answer, as both mass and lifetime both increase.		**1**
5	**The only correct answer is D** A is not the correct answer, as centripetal force keeps car moving with circular motion B is not the correct answer, as centripetal force keeps car moving with circular motion C is not the correct answer, as this would keep car moving with circular motion		**1**
6	**The only correct answer is D** A is not the correct answer, as efficiency = useful output/input = 40/44		**1**

	B is not the correct answer, as efficiency = useful output/input = 40/44 C is not the correct answer, as efficiency = useful output/input = 40/44		
7	**The only correct answer is D** A is not the correct answer, as change in momentum is the same. B is not the correct answer, as change in velocity is the same. C is not the correct answer, as force decreases.		**1**
8	**The only correct answer is C** A is not the correct answer, as P,E. increases and speed decreases as particle approaches nucleus B is not the correct answer, as P,E. increases and speed decreases as particle approaches nucleus D is not the correct answer, as P,E. increases and speed decreases as particle approaches nucleus		**1**
9	**The only correct answer is D** A is not the correct answer, as electrons will not deflect particle. B is not the correct answer, as neutral atom will not deflect particle. C is not the correct answer, as this cannot be concluded from observing just one particle.		**1**
10	**The only correct answer is B** A is not the correct answer, as the gradient of the velocity graph must increase. C is not the correct answer, as the gradient of the velocity graph must increase. D is not the correct answer, as as the gradient of the velocity graph must increase.		**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers		Additional guidance	Mark
11(a)	An explanation that makes reference to the following points: • current (in coil) produces a magnetic field/flux • (a.c.) leads to changing (magnetic) field/flux through pan • induces an emf in pan • leads to current (in pan because it is an electrical conductor) MP4 dependent on MP2	**(1)** **(1)** **(1)** **(1)**	MP2 – 4 must relate to the pan	**4**
11(b)	An explanation that makes reference to the following points: • high frequency means that flux/field is changing quickly **Or** increases rate of change of flux/field • leads to increased (induced) emf (in pan) **Or** leads to increase in (induced) current (in pan) MP2 dependent on MP1	**(1)** **(1)**		**2**

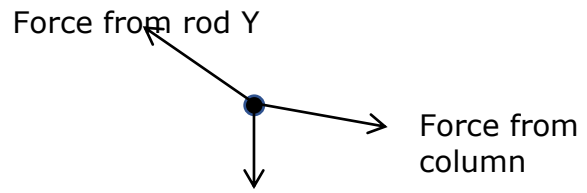
(Total for Question 11 = 6 marks)

Question Number	Acceptable answers		Additional guidance	Mark
12(a)	• A vector has magnitude and direction	**(1)**		**1**
12(b)	An explanation that makes reference to the following points: • States $I = nqvA$ **Or** n and q stated as constant **Or** $v \propto \frac{1}{A}$ • v must increase (if A decreases) MP2 dependent on MP1	**(1)** **(1)**		**2**
12(c)	**Either** • j has units A m^{-2} • E has units V m^{-1} or N C^{-1} • ρ has units of Ω m • Algebra to show units the same on both sides **Or** If formulas have been used: • Substitution using $\rho = RA/l$ • Substitution using $E = V/d$ • Substitution using $R = V/I$ • The equations above and $j = I/A$ need to be rearranged and simplified with Ω (or R) appearing on either side	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	Example: Units of $\frac{E}{j} = \frac{\text{Vm}^{-1}}{\text{Am}^{-2}} = \Omega\text{m}$ and these are the units of ρ **Or** find agreements for both sides using options shown below: Units of $\frac{E}{J}$ are $\frac{\text{N C}^{-1}}{\text{Am}^{-2}} = \frac{\text{Nm}^2}{\text{AC}} = \frac{\text{Jm}}{\text{AC}} = \frac{\text{kgms}^{-2}\,\text{m}^2}{\text{A}^2\text{s}} = \frac{\text{kgm}^3\text{s}^{-3}}{\text{A}^2}$ Units of $\rho = \Omega\text{m} = \frac{\text{V}}{\text{A}}\text{m} = \frac{\text{Nm}^2}{\text{CA}} = \frac{\text{Jm}}{\text{CA}}$ $= \frac{\text{kgms}^{-2}\text{m}^2}{\text{A}^2\text{s}} = \frac{\text{kgm}^3\text{s}^{-3}}{\text{A}^2}$	**4**

(Total for Question 12 = 7 marks)

Question Number	Acceptable answers	Additional guidance	Mark
13(a)	• 30 lux corresponds to 3000 Ω **(1)** • Use of ratio of resistances **(1)** • Use of corresponding ratio of p.d.s **(1)** • To a p.d. of 0.7 (V) **(1)** • if light goes above this level then resistance of LDR decreases **(1)** • so p.d. to transistor increases so does perform as required **(1)** MP6 dependent on MP5	Example of calculation $\frac{V}{7.0} = \frac{333}{333 + 3000}$ $V = 0.70$ V Alternative for MP2 and MP3 • Use of $I = V/R$ for whole circuit • Use of $V = IR$ for 333 Ω resistor Example of calculation $I = 7.0$ V/ $(333 + 3 \times 10^3)$ Ω $= 2.1 \times 10^{-3}$ A $V = 2.1 \times 10^{-3}$ A ×333 Ω = 0.7 V	**6**
13(b)	An explanation that makes reference to the following points: • more electrons move into a conduction band **Or** more electrons become free **(1)** • with (increased light level) so resistance decreases **(1)** MP2 dependent on MP1		**2**

(Total for Question 13 = 8 marks)

Question Number	Acceptable answers		Additional guidance	Mark
14(a)(i)	• Attempt to take moments around right hand end of X • Use of $W = mg$ • Correct component of T or perpendicular distance to T • $T = 890$ N	**(1)** **(1)** **(1)** **(1)**	distance of 1.5 m used with 45 Or 1.3 m used with T Example of calculation $45\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times 1.5\ \text{m} = T \times 1.3\ \text{m} \times \sin 35$ $T = 888$ N	**4**
14(a)(ii)	• (thrust) arrow approx 35° to horizontal to the upper left • arrow direction capable of balancing opposite pair	**(1)** **(1)**	Do not penalise whether force from column is above/below/on the horizontal  	**2**
14(b)	• Use of $E = \frac{\text{constant}}{r^2}$ • Calculates at least one value of the constant • Calculates a second value and states that the field is not inverse square law	**(1)** **(1)** **(1)**	eg writes $Q = 4\pi\varepsilon_0 E r^2$ Or $Q/4\pi\varepsilon_0 = Er^2$ Or $Er^2 = k$ Example of calculation $1200\ \text{N C}^{-1} \times 3^2\ \text{m}^2 = 10800\ \text{V m}$ $100\ \text{N C}^{-1} \times 25^2\ \text{m}^2 = 62500\ \text{V m}$ Or $1200\ \text{N C}^{-1} \times 3^2\ \text{m}^2 \times 4\pi\varepsilon_0 = 1.2 \times 10^{-6}\ \text{C}$ $100\ \text{N C}^{-1} \times 25^2\ \text{m}^2 \times 4\pi\varepsilon_0 = 6.9 \times 10^{-6}\ \text{C}$ Or $1200\ \text{N C}^{-1} \times 3^2\ \text{m}^2 = 10800\ \text{V m}$ $\frac{10800\ \text{V m}}{100\ \text{N C}^{-1}} = 108\ \text{m}^2$ and $\sqrt{108} = 10.4$ not 25	**3**

(Total for Question 14 = 9 marks)

Question Number	Acceptable answers	Additional guidance	Mark
15(a)(i)	• Leaves no track **(1)** **Or** the tracks present are opposite curvatures		**1**
15(a)(ii)	• proton is positive **(1)** • conservation of charge means pion is negative **(1)** **Or** opposite curvature to proton means pion is negative	both marks can be given for 0 = +1 -1 with pion identified as negative.	**2**
15(a)(iii)	• $(\Delta^0) \rightarrow p^{(+)} + \pi^-$ **(1)**	Allow ecf if pion was stated as positive in (ii)	**1**
15(a)(iv)	• baryon number conserved **Or** baryon number is +1 on both sides of equation **Or** proton is baryon and the pion is not a baryon **(1)**		**1**
15(a)(v)	An explanation that makes reference to the following points: • The radius of the proton path is (very) large (compared with the pion) **(1)** • According to $p = BQr$ **(1)** • The momentum of the proton is larger than the momentum of the pion. (dependent on MP2 or MP1) **(1)**	Allow proton path is less curved Allow $p \propto r$	**3**
15(b)(i)	• Converts eV to J **(1)** • use of $\Delta m = \Delta E / c^2$ **(1)** • mass = 2.19×10^{-27} (kg) **(1)**	Example of calculation $m = \frac{1232\ \text{V} \times 1.6 \times 10^{-19}\text{C} \times 10^6}{(3 \times 10^8)^2 (\text{ms}^{-1})^2}$ $m = 2.19 \times 10^{-27}\ \text{kg}$	**3**

15(b)(ii)	• Calculates mass difference **Or** states (total) mass of decay products is less than mass of delta particle **(1)** • According to $\Delta E = \Delta mc^2$ **(1)** • becomes (extra) E_k (between decay products) **(1)**	<u>Example of Calculation</u> 939 + 139 = 1078 1232 – 1078 = 154(MeV/c^2) Or 1232 is more than 1078(MeV/c^2)	**3**

(Total for Question 15 = 14 marks)

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr>
<td>*16(a)</td>
<td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

Indicative content:

• Current direction is D to C in coil
Or Current direction is B to A (1)

• There is a force due to current (carrying conductor) within a magnetic field (1)

• The force is vertically down on side DC
Or The force is vertically up on side BA (1)

• Moment of force (around axis) produces rotation (in an anticlockwise direction) (1)

• as coil moves through half a turn split ring ensures the current switches direction (for a particular side) (1)

• This results in the coil continuing to rotate (in the same direction) (1)
</td>
<td>
<table>
<tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
Arrows could be added to the diagram

Accept $F=BIl$

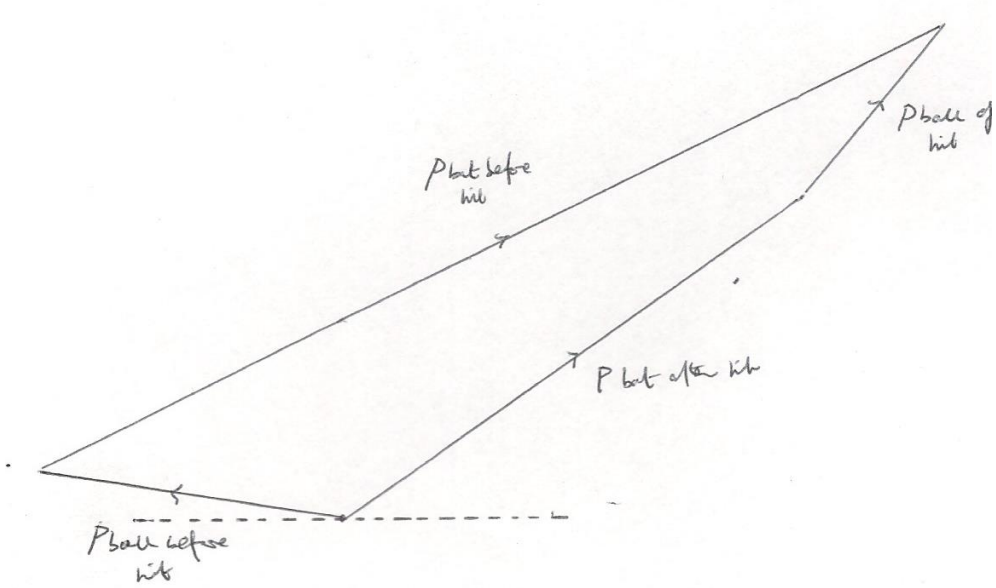
allow ecf if current direction is defined/indicated in the opposite direction
</td>
<td>6</td>
</tr>
</table>

16(b)	• Use of $P = W/t$ **(1)** • Use of $E_k = ½ mv^2$ **(1)** **Or** use of SUVAT, $F = ma$ and $W=Fs$ • Work done = 8.0×10^5 J **(1)**	Example of calculation Work done by motor = 390×10^3 W × 4.0 s = 1.56×10^6 J $E_k = ½$ 1950 kg × 28^2 (m s^{-1})^2 = 764400 J Work done by resistive forces = 1.56×10^6 J −764400 = 795600 J Second example of MP2 $a = \frac{28 \text{ m s}^{-1} - 0}{4.0 \text{ s}} = 7.0 \text{ m s}^{-2}$ Resultant force = 1950 kg×7.0m s^{-2}=13650 N $s = \frac{0+28 \text{ m s}^{-1}}{2} \times 4.0 \text{ s} = 56 \text{ m}$ Work to increase velocity = 13650 N × 56 m = 764400 J Work done by resistive forces = 1.56×10^6 J −764400 = 795600 J	**3**
16(c)	An explanation that makes reference to the following points: Energy Argument: • More energy transferred in the battery (rather than the motor) **(1)** • The battery/car will be less efficient **(1)** • Therefore the battery will need charging more often **Or** journey will be shorter **(1)** Force/Power Argument: • Increased internal resistance reduces terminal p.d. **(1)** • reduces the current (in the circuit) **(1)** • So acceleration of car is reduced **O**r less power **Or** battery will take longer to charge **(1)**	Accept reference to heating effect in the battery	**3**

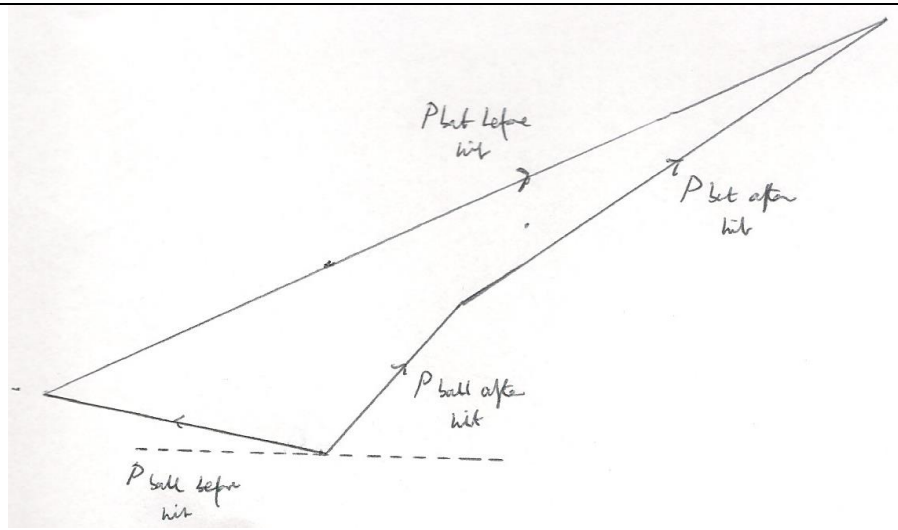
(Total for Question 16 = 12 marks)

Question Number	Acceptable answers	Additional guidance	Mark
17(a)	• Uses correct components of velocity **(1)** • Uses $v = d/t$ in the horizontal plane **Or** Uses any equation of motion in the horizontal plane **(1)** • Uses $s = ut + ½ at^2$ **(1)** • the ut term has the opposite sign to the term at^2 **(1)** • s = 2.1 m so fielder can catch the ball because it is less than 3 m **(1)** (allow rounding error in final answer)	Example of calculation Initial vertical component velocity = 23.8 sin50 = 18.23 m s^{-1} Horizontal component velocity = 23.8 cos50 = 15.30 m s^{-1} t = 55.0 m / 15.30 m s^{-1} = 3.595 s $s = 18.23\text{m s}^{-1} \times 3.595\text{ s} - \frac{9.81\text{ m s}^{-2} \times 3.595^2\text{ s}^2}{2}$ s = 65.5 m – 63.4 m = 2.1 m Or starts the same with v_H and v_V $3.0\text{ m} = 18.23\text{m s}^{-1} \times t - \frac{9.81\text{ m s}^{-2} \times t^2}{2}$ t = 3.54 s s = 15.30 m s^{-1}×3.54 s = 54.2 m So at s = 55 m the ball will be below 3 m and can be caught	**5**
17(b)(i)	• p = 3.33 (N s) **(1)**	Example of calculation $p = 0.140\text{ kg} \times 23.8\text{ m s}^{-1}$ p = 3.33 kg m s^{-1}	**1**
17(b)(ii)	• Draws labelled vector line with a ruler representing $p_{\text{ball after}}$ **(1)** • at approximately the correct angle (50^o) **(1)** • length of line scaled correctly **Or** recognises the scale is 1 cm = 1 N s **(1)** • either $p_{\text{ball after}}$ line **or** $p_{\text{bat after}}$ line should start at the start of the $p_{\text{ball before}}$ line. **(1)**	Accept a label such as "ball after" ie length of $p_{\text{ball after}}$ should be about 3(.3) cm This can only be given if there is a correct arrow and either label	**5**

	• Momentum = 8.3 (N s) ∓ 0.3 and angle = 34° ∓ 3° **(1)**		



Or



(Total for Question 17 = 11 marks)

Question Number	Acceptable answers		Additional guidance	Mark
18(a)(i)	• Vrms = 3.5 V	**(1)**	Example of calculation $V_{\text{rms}} = \frac{5}{\sqrt{2}}$ =3.54 V	**1**
18(a)(ii)	An explanation that makes reference to the following points: • "5" is the peak value (of pd) • Use of $T = 1/f$ **Or** $\omega = 2\pi/T$ **Or** $\omega = 2\pi f$ • Uses $\omega = 100\pi$ to show that the time period should be 0.02 s **Or** Uses $f = 50$ to show that sin $2\pi ft$ is sin $100\pi t$ **Or** Uses $T = 0.02$ to show that $100\pi 0.02 = 2\pi$	**(1)** **(1)** **(1)**	Accept max for peak Alternative MP2: recognises that one period/cycle of the sine wave is an angle of 2π	**3**
18(b)(i)	• $Q = CV$ **Or** E10 = C10 * C • where $C = 0.001$ (F) MP2 dependent on MP1	**(1)** **(1)**		**2**
18(b)(ii)	• $I = \Delta Q / \Delta t$ **Or** G11 = F11 / B11	**(1)**		**1**
18(b)(iii)	• Use of $W = \frac{1}{2}CV^2$ **Or** $W = ½\ QV$ **Or** $W = \frac{1}{2}\frac{Q^2}{C}$ • $W = 0.0125$ J	**(1)** **(1)**	Example of calculation $W = \frac{1}{2} 0.001\ \text{F} \times 5^2\ \text{V}^2 = 0.0125$ J $W = \frac{1}{2} 0.005\text{C} \times 5\text{V} = 0.0125$ J	**2**
18(c)	• States $P = IV$ • any two corresponding values of I and V used to calculate a value of P • observation that at different times P is negative or positive • Overall power dissipated by capacitor is zero	**(1)** **(1)** **(1)** **(1)**	Graph could be marked with values/lines/power curve Alternative MP2: recognise the symmetry of either quarter or half cycles of the graphs	**4**

(Total for Question 18 = 13 marks)

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